detailed observations on such subjects as hygroscopicity, the régime of the shrinking and swelling seeds, the dehiscence of fruits, the proportion of parts in fruits, the abortion of ovules, seed coloration, the weight of the embryo, the rest-period of seeds and a philosophic chapter (XX.) on the cosmic adaptation of the seed in which the author states his belief that the seed is less specialized and less conditioned than the plant; that its potentialities present us with a range of life-conditions that extends beyond the earth and offers a clue to the conditions of existence in other worlds. Finally Guppy postulates a flora of the cosmos.

Although the author allows himself in the last chapter to be spirited away from things mundane, yet, the whole work is pervaded with the spirit of thorough scientific research in which no fact is overlooked which might bear on the main problem of seed investigation, and each fact is submitted to rigid examination, by the balance and other instruments of precision. The book has been overlooked apparently by other American botanic reviewers and it deserves a place on the shelves of any library that attempts to be stocked with recent important contributions to botanic science.

John W. Harshberger
University of Pennsylvania

SPECIAL ARTICLES

A NEW MARKING SYSTEM AND MEANS OF MEASURING MATHEMATICAL ABILITIES[1]

Perhaps the most noted methods of measuring the intelligence of young children are the De Sanctis and the Binet-Simon tests. These tests apply mainly to the measurement of lower levels of intelligence. It is very significant that the noted Italian and French psychologists who originated these tests did not extend the general method to be used with pupils of the secondary and higher schools. In the present state of educational psychology it does not seem practicable or possible to effect successfully such an extension; that is to say, it is improbable that such tests can be devised which can be applied to everyday use in our schools, and will be a real improvement upon our present system of examinations, in settling questions of promotion and in awarding honors in our high schools and colleges. We are able to determine certain questions of athletic proficiency by measuring the high jump or broad jump, by timing the quarter-mile or half-mile run. The fact that the candidate knows beforehand the nature of the test does not materially interfere with its efficiency. But if a candidate for promotion knows beforehand the exact nature of the test in algebra—as he easily may know, if tests are adopted to be used by all teachers at all times—then he can easily learn the few tests and make a high grade, even though his knowledge of the entire subject may be woefully deficient. It is quite evident that it is impossible to formulate specific questions in any branch of high-school mathematics, which could be used everywhere and at all times. Yet the report of the American Committee No. VII. on Examinations in Mathematics contains the following:[2]

> There seems to be a pronounced desire throughout the country for standardized tests in mathematics, that is, tests which will enable teachers to measure fairly accurately the efficiency of their instruction and to know whether their pupils are as proficient as those in other localities.

One way to meet this demand is to prepare a syllabus of essentials in high-school arithmetic, algebra and geometry, to be used in preparing the specific questions for an examination. Such a syllabus has its merits and also its demerits. Its merits are that both teachers and pupils have the territory to be covered by the examination more definitely limited to what are the essentials. Its demerits are that it leads both teachers and pupils to a disregard of the many minor facts of a science, which deserve at least passing notice.

[1] Read before the mathematics section of the Central Association of Science and Mathematics Teachers, November 29, 1913, at Des Moines, Iowa.

[2] U. S. Bureau of Educ., *Bulletin*, 1911, No. 8, p. 13.

Nor does the use of such a syllabus prevent the selection by one teacher of only easy exercises, and by another teacher of only hard exercises. It is my opinion that the value of a syllabus is overestimated, that our high-school text-books do not differ widely in the amount of material, nor in the degree of difficulty of the exercises contained therein. If a teacher carefully prepares a set of questions which, taken as a whole, are of average difficulty, he may rightly assume that he has a standard test. Notice my use of the word "carefully." No system of marking, however perfect, can be successful, if the teacher does not exercise *care*. A 12-inch disappearing gun will not defend Panama unless there is a careful eye to train it.

Granted that a standard set of questions is at hand, are our difficulties solved? Have we an absolute system of marking? By no means. Every one knows that two teachers seldom agree on the marking of the same examination paper. They differ often by 10 or 20, and sometimes even by 30 points on the scale of 100. Suppose a pupil in algebra makes a mistake in algebraic sign, but otherwise answers a question correctly. One teacher will attribute the error to mere oversight, and mark the question nearly perfect. Another teacher will be horrified at the ignorance of fundamentals, and will mark the same question nearly 0. Such discrepancies will arise even in the use of the Binet-Simon system. That system does not eliminate the lopsidedness of the examiner. One of the questions put to a child of ten is this: "What would you do if you were delayed in going to school?" Various replies may follow, as, for instance, "I would have to hurry," "I would have to run," "I would return home," "I would be punished," "The teacher would slap me," "I would not do it again." Do you believe that in such a variety of answers which children may give, any two examiners would agree in their markings? "I would be punished" does not answer the question. Accordingly, some examiners would mark 0. Other examiners would say that the reply not only implies that the question was properly understood, but that the child's mind passed beyond the immediate reply, that it "would have to hurry," and gave expression to a possible consequence that was more remote and therefore indicative of greater intellectuality. The diversity of estimates would be as conspicuous here as in any ordinary examination. As yet we are as far as ever from an accurate standard of marking.

But a more or less absolute standard of marking is the very thing we are after. We need a common mode of procedure, such that a mark of "excellent" in first-year geometry, given by a teacher this year, means nearly the same thing as a mark of "excellent" in this subject that will be given by a teacher twenty years from now. We need a system of marking such that a mark expressed in numbers conveys to every one a fairly uniform and definite idea of proficiency. During the last few years great progress has been made in devising plans toward achieving this end. What I shall present to you to-day contains little that is novel. In this matter I follow in the foot-steps of Cattell,[3] Colvin,[4] Dearborn,[5] Finkelstein,[6] Foster,[7] Hall,[8] Herschel,[9] Huey,[10] Judd,[11] Meyer,[12] Sargant,[13] Smith,[14] Steele,[15] Stevens,[16] Starch[17] and others.

[3] J. M. Cattell, *Popular Science Monthly*, Vol. 66, 1905, p. 367.

[4] S. S. Colvin, *Education*, Vol. 32, 1912, p. 560.

[5] W. F. Dearborn, *Bulletin of the University of Wisconsin*, 1910, No. 368.

[6] I. E. Finkelstein, "The Marking System in Theory and Practice," 1913.

[7] W. F. Foster, SCIENCE, Vol. 35, 1912, p. 887; *Popular Science Monthly*, Vol. 78, 1911, p. 388; "Administration of the College Curriculum," 1911, Chap. 13.

[8] W. S. Hall, *School of Science and Mathematics*, Vol. 6, 1906, p. 501.

[9] W. H. Herschel, *Bull. of Soc. from Prom. of Engineer. Education*, Vol. 3, 1913, p. 529.

[10] E. B. Huey, *Journal of Psycho-Asthenics*, Vol. 15, 1910, p. 31.

[11] C. H. Judd, *School Review*, Vol. 18, 1910, p. 460.

[12] M. Meyer, SCIENCE, Vol. 28, 1908, p. 243; Vol. 33, 1911, p. 661.

[13] E. B. Sargant, *Nature*, Vol. 70, 1904, p. 63.

[14] A. G. Smith, *Journal of Educational Psychology*, Vol. 2, 1911, p. 383.

Our scheme of measuring mathematical abilities resolves itself into two parts, as follows:

1. A formula for "arraying" students in order of ability, that is, for determining the relative positions of the members of a class, so as to establish the order of merit, or the rank of each individual in the group. This formula furnishes also preliminary estimates of ability.

2. A revision of these preliminary estimates so as to supplant them by an absolute standard.

Part I

Mathematical ability depends in part upon knowledge of a subject and proficiency in carrying on accurately the mechanical operations connected with it. This kind of ability may be determined by the usual memory tests conducted from day to day in the class-room, and at longer intervals by examination.

Mathematical ability is measured also by the success in solving original exercises. These tests are made in daily work, and also in final examinations.

The observation of instructors and the teachings of the history of science suggest a still further test of mathematical power, namely, the diligence or tenacity displayed by a pupil in pursuing his work. A pupil of only average talents, but of great tenacity of purpose, may achieve more in his life than a bright pupil of limited powers of application. A standard illustration is the case of Robert Mayer, who as a pupil made only a moderate record, but who, by his extraordinary tenacity of purpose was led to the discovery of the law of the conservation of energy.

In Germany and Switzerland this feature is being recognized in the records and reports of scholarship. When I was a boy I received two marks on every subject, one for *Fleiss,* or diligence, the other for *Fortgang,* or progress. In Germany this practise is in vogue to-day.

According to our scheme, the mathematical pupil is measured in three ways, as follows:

1. By memory tests
   (*a*) In daily work.............. *Ma*
   (*b*) In examination............ *Mb*
2. By original exercises
   (*a*) In daily work.............. *Oa*
   (*b*) In examinations............ *Ob*
3. By diligence (tenacity) shown.... *D*

How these marks should be combined might be a subject of legitimate debate. Following custom, we use the weighted arithmetic mean, as follows:

$$\text{Preliminary Mark} = \frac{M_a + rM_b + sO_a + tO_b + uD}{1 + r + s + t + u}$$

where r, s, t, u are coefficients determining relative weights. What weight should be given to daily work, what to the examination? In different schools the weights vary from daily work $\frac{4}{5}$, final examinations $\frac{1}{5}$, to daily work $\frac{1}{2}$ and final examination $\frac{1}{2}$. A conservative estimate would be to take $s = 1$, $r = t = u = \frac{1}{3}$.

Part II

After the relative place or rank of the students in a class has been determined by the process of Part I., we proceed to determine their marks on an absolute scale. We shall assume that the pupils constitute a random sample or "fair sample" of the student body. What is the distribution of mental ability, and of mathematical ability in particular? No one has been able to give a final answer to this question. Francis Galton, Karl Pearson and others have held that individuals differ from each other in ability in such a way as to conform with what is known as the "normal frequency curve" or the "normal curve" or the "Gaussian curve." Distances along the horizontal line measure the students' abilities. The corresponding ordinates of this bell-shaped curve indicate the frequency. In measuring physical characteristics, it is easy to tell whether or not the above curve represents the proper distribution. It is a singular fact that this curve has been found to represent a general biological

[15] A. G. Steele, *Pedagogical Seminary,* Vol. 18, 1911, p. 523.

[16] W. L. Stevens, *Popular Science Monthly,* Vol. 63, 1903, p. 312.

[17] D. Starch, *Psychol. Bulletin,* Vol. 10, 1913. p. 74; Science, Vol. 38, 1913, p. 630.

law of variation. Natural phenomena, as well as chance, tend to fluctuate in a manner indicated by this curve. Chest measurements on 5,738 soldiers[18] show the close agreement with theory. The stature of 1,052 English women[19] was found by Karl Pearson to closely obey the Gaussian law. Some of the lower mental traits can be measured in the psychological laboratory. Thorndike[20] found twelve-year-old pupils to be distributed according to the Gaussian curve as regards their accuracy and rapidity of perception. Memory tests yielded similar results. When it comes to tests of higher intellectual powers, records are discordant. Different examiners have varied to such a marked degree in marking the same individuals that conclusions can not be safely drawn from their estimates. On account of the presence of constant errors, the lopsidedness of individual markings can not be altogether eliminated by taking the averages of many grades from different examiners. A curve constructed from 1,487 grades in mathematics given by 19 different teachers in three high schools in Colorado exhibits two peaks with a valley between. The first peak is at 70 per cent., the passing mark; the other peak is just above 85 per cent. Evidently the peak at 70 per cent. is due to a constant error arising from the practise of raising marks of some pupils to the passing grade. Such constant errors arise also where a mark of 85 per cent. on the daily work exempts students from final examinations. It is found that in such cases medium grade students are advanced to the exempt limit. Seldom are marks given between 55 and 59, where 60 is the passing grade. If a doubtful student is finally passed, some teachers give him a mark considerably above passing, the idea being[21] that, if passed at all, he ought to be passed "handsomely." The tendency to mark high is inherent in human nature. Dr. Ruffner says:[22]

> A temporizing professor who loves popularity and desires, like the old man in the fable, to please everybody, is sure to be guilty of this fault, and, like many a politician, to sacrifice permanent good for temporary favor.

For these reasons, available statistics as to the distribution of mental abilities are inconclusive. Some empirical curves indicate considerable skewness, others follow the Gaussian curve. President Foster found that 8,969 grades in 21 elementary courses for two years at Harvard obeyed the normal curve of frequency. Dearborn makes similar reports for 472 high school pupils, also for freshman grades of these same pupils at the University of Wisconsin. It is doubtless the principle of continuity that has led not only English statisticians like Galton and Pearson, but also American investigators, Foster, Meyer, Smith, Dearborn, Finkelstein and others, to aver that the Gaussian curve or normal curve is the proper curve for the distribution of marks in school. In what follows we assume that the Gaussian curve can be so used.

The question then arises, what marks should be assigned to a random group or "fair sample" of, say, twenty students, whose order of rank is known by the tests suggested in Part I. This question involves some intricate statistical theory, which has been worked out by Karl Pearson. Pearson[23] states the problem thus:

> A random sample of n individuals is taken from a population of N members which when N is very large may be taken to obey any law of frequency expressed by the curve $y = N\phi(x)$, ydx being the total frequency of individuals with characters or organs lying between x and $x + dx$. It is required to find an expression for the average difference in character between the pth and the $(p+1)$th individual when the sample is arranged in order of magnitude of the character.

In answering this question, Pearson de-

[18] L. A. Quetelet, "Lettres sur la théorie des probabilités," p. 400. See also A. L. Bowley, "Elements of Statistics," London, 1902, p. 278; Dearborn, *op. cit.*, p. 8.

[19] Cattell, *op. cit.*, p. 371; Dearborn, *op. cit.*, p. 9.

[20] Thorndike, "Educational Psychology," p. 15.

[21] Finkelstein, *op. cit.*, p. 42.

[22] Quoted by Finkelstein, *op. cit.*, p. 47.

[23] Karl Pearson, "Note on Francis Galton's Problem," *Biometrica*, Vol. 1, pp. 390–399.

rives complicated formulas which we have used in calculating our data. Pearson himself felt that he had solved an important question, for he said:

AVERAGE DIFFERENTIAL ABILITIES OF PUPILS CHOSEN AT RANDOM[24]

Arbitrary Divisions	Class of 20		Class of 30		Class of 40		Class of 50		Class of 100	
	Rank	Mark/*s*	Rank	Mark/*s*	Rank	Mark/*s*	Rank	Mark/*s*	Rank	Mark/*s*[25]
Excellent Above +1.5	1	1.9	1	2.1	1	2.2	1	2.3	1	2.5
			2	1.6	2	1.8	2	1.9	2	2.2
					3	1.5+	3	1.6	3	2.0
									4	1.8
									5	1.7
									6	1.6
									7	1.5+
Superior +.5+ to +1.5	2	1.4	3	1.4	4	1.4	4	1.5	8, 9	1.4
	3	1.1	4	1.2	5	1.2	5	1.3	10, 11	1.3
	4	.9	5	1.0	6	1.1	6	1.2	12, 13	1.2
	5	.8	6	.9	7	1.0	7	1.1	14, 15	1.1
	6	.6	7	.8	8	.9	8, 9	1.0	16, 17	1.0
			8	.7	9	.8	10	.9	18–20	.9
			9	.6	10	.7	11	.8	21–23	.8
					11	.6	12, 13	.7	24–26	.7
					12	.6	14	.6	27–29	.6
							15	.6	30, 31	.5+
Medium −.5 to +.5	7	.5	10	.5	13	.5	16	.5	32, 33	.5
	8	.3	11	.4	14, 15	.4	17, 18	.4	34–36	.4
	9	.2	12	.3	16	.3	19, 20	.3	37–40	.3
	10	.06	13	.2	17, 18	.2	21, 22	.2	41–44	.2
			14	.1	19	.1	23, 24	.1	45–48	.1
			15	.04	20	.03	25	.02	50	.01
			16	−.04	21	−.03	26	−.02	51	−.01
	11	−.06	17	−.1	22	−.1	27, 28	−.1	53–56	−.1
	12	−.2	18	−.2	23, 24	−.2	29, 30	−.2	57–60	−.2
	13	−.3	19	−.3	25	−.3	31, 32	−.3	61–64	−.3
	14	−.5	20	−.4	26, 27	−.4	33, 34	−.4	65–67	−.4
			21	−.5	28	−.5	35	−.5	68, 69	−.5
Inferior −1.5 to −.5+	15	−.6	22	−.6	29	−.6	36	−.6	70, 71	−.5+
	16	−.8	23	−.7	30	−.6	37	−.6	72–74	−.6
	17	−.9	24	−.8	31	−.7	38, 39	−.7	75–77	−.7
	18	−1.1	25	−.9	32	−.8	40	−.8	78–80	−.8
	19	−1.4	26	−1.0	33	−.9	41	−.9	81–83	−.9
			27	−1.2	34	−1.0	42, 43	−1.0	84, 85	−1.0
			28	−1.4	35	−1.1	44	−1.1	86, 87	−1.1
					36	−1.2	45	−1.2	88, 89	−1.2
					37	−1.4	46	−1.3	90, 91	−1.3
							47	−1.5	92, 93	−1.4
Poor Below −1.5									94	−1.5+
									95	−1.6
									96	−1.7
									97	−1.8
					38	−1.5+	48	−1.6	98	−2.0
			29	−1.6	39	−1.8	49	−1.9	99	−2.2
	20	−1.9	30	−2.1	40	−2.2	50	−2.3	100	−2.5

[24] For practical use this table should be considerably extended.

[25] The marks for a class of 100 are adapted from the tables of H. L. Moore's "Laws of Wages," New York, 1911, pp. 98, 99. Moore computed his table to six decimals. He applies Pearson's statistical theory to the study of "wages and ability."

This difference problem marks a new and very probably most important departure in statistical theory.

Clearly a knowledge of the average difference in scholarship of adjacent individuals supplied by Pearson's formulas involves also a knowledge of the average difference in scholarship between any two individuals. We shall display in our tables the difference between the modal or most frequent scholarship of the class and the scholarship of any individual in the class.

The columns headed "mark/s" signify the ability of the pupil above or below the modal ability, divided by s, the standard deviation of the total group of students (say first year high school students) from which the particular class is taken at random as a "fair sample." It will be noticed that a large standard deviation indicates a large range of distribution—that is, a large difference of accomplishment between the best and poorest in the class. In freshman classes the standard deviation is apt to be large, because of great difference in preparation. For our purposes, the exact value of the standard deviation is of no interest. We are concerned more with the ratios of differential abilities than with their absolute values. Hence we shall take $s = 1$, or, if more convenient, $s = 10$.

Consider a class of 20 pupils. The modal or "mediocre" ability is taken here, as in the other cases, as the standard of reference and is marked 0. Abilities of students are arranged symmetrically above and below, and marked positive and negative. By subtracting the ability of a pupil of rank n from that of his neighbor below, we get the differential ability of the two. In a class of twenty the difference in average ability between the tenth and eleventh pupil is .13. The difference between the first and second pupil is .5. Thus the difference between the first and second pupils is about four times greater than the difference between the tenth and eleventh. Similar statements apply to the poorest pupil and the one next above him. These relations are brought out by the adjoining figure.

Distances measured to the right and left of the zero point signify abilities above and below the modal ability. The relative standings of the members of an average class of 20 are indicated by the dots. Observe the denseness of the dots near the modal position and the isolation of those at the ends.

FIG. 1.

When the number of pupils in a class is larger, the differential ability of the pupils ranking next to each other becomes smaller. Thus in a class of 100, the difference between the first and second is on an average .3, that between the 50th and 51st is on an average .02, but the former difference is about 15 times greater than the second. The importance of these relations is brought out by Pearson in the following words:

> It is not possible to pass over the general bearing of such results on human relations. If we define "individuality" as difference in character between a man and his compeers, we see how immensely individuality is emphasized as we pass from the average or modal individuals to the exceptional man. Differences in ability, in power to create, to discover, to rule men, do not go by uniform stages. We know this by experience, but we see it here as a direct consequence of statistical theory, flowing from a characteristic and familiar chance distribution. We ought not to be surprised, as we frequently are, at the results of competitive examination, where the difference in marks between the first men is so much greater than occurs between men towards the middle of the list. In the same way the individuality of imbeciles and criminals at the other end of the intellectual and moral scales receives its due statistical appreciation.

The total range of distribution for classes of random pupils not exceeding 100 is about $2.5s$ on each side of the modal line, where s is the standard deviation. Taking $s = 1$ or $s = 10$ we have a scale for marking, the objec-

tion to which lies mainly in the fact that it is new. But this scale is the most scientific yet proposed. It is based on careful, statistical theory.

The mode of distribution of mental abilities, exhibited in the normal curve, suggests that the scale be subdivided into an odd number of parts, so that there may be a central group, representing average students, which is the most common type of students. The other groups are placed symmetrically above and below this central group. What should be the total number of groups? Experience shows that three groups are hardly sufficient, that seven groups are excessive. The five-group system is altogether in nearest accord with experience. Accordingly, we shall use the terms "Excellent," "Superior," "Medium," "Inferior," "Poor," and define their positions on the Pearson scale, thus:

Poor	Inferior	Medium	Superior	Excellent
Below — 1.5	— 1.5 to — .5 +	— .5 to + .5	.5 + to +1.5	Above + 1.5

When a class of 20, 30 or 40 pupils has to be marked, we first determine the ranks of the pupils. Then the numerical values of these tables are a suggestion as to the probable marks to be assigned. For any one class of 20 these tabular figures are, of course, not binding. If a large number of different classes of 20 could be marked with absolute accuracy, the *averages* of the marks of all the pupils that take the rank n in the lists of twenties would yield the values given in the tables. Thus the averages of the students ranked fifth in different classes of twenty students each, is .8. What deviation from the tabular marks should be made in the case of any particular class because of its individual variation or its deviation from a "fair sample" must lie with the judgment of the instructor. The position of the exact line of cleavage between pupils "passing" and those "not passing" must rest with him. It is my own judgment that, *if teachers were to follow very closely the tabular marks, and were to modify them in only exceptional cases, and then only slightly, that a great stride would be taken toward a scientific and absolute method of marking.* Gross irregularities in marking, such as Finkelstein has found in Cornell, and such as we know to exist in schools with which we are connected—irregularities working great injustice to pupils aspiring to honors and to scholarships—would be eliminated by the adoption of a plan as herein set forth. Every one knows that the marking system as carried on at present in high schools and colleges is a farce. But the adoption of a scheme of marking as here proposed would show that a mark of 0 places the pupil in a modal position, as a mediocre student. A mark above 1.5 places him in the list of the very few branded "excellent." A mark below — 1.5 places him near the line of students marked "not passed."

In nearly all the marking systems that have been suggested in recent years, the recommendation is made that, under normal conditions, a certain percentage of the class be marked "excellent," another percentage "superior," etc. The Missouri plan involves the same idea by dividing each class of 100 into four groups of 25 students each, and then subdividing the first and last groups again into two classes. I have never seen it pointed out that *such a procedure, as a matter of fact, rests upon an unsound basis.* The tabular data computed from Pearson's formulas show that if, for instance, we mark 7 per cent. of a class of 100 "excellent," we have a different standard of "excellence" from what we have when 7 per cent. of a class of 50 is marked "excellent." The difference in standard is slight, but it exists, and therefore renders the percentage basis scientifically objectionable. To illustrate: When 7 per cent. of the class are marked "excellent," the lower limit for this mark on the Pearson scale is (using more accurate results than those in our table) 1.4390 for a class of 100, 1.4045 for a class of 50, 1.3951 for a class of 40, 1.3529 for a class of 30, and 1.3080 for a class of 20. Seven per cent. of a class of 41 members is four, but only three of the four stand above the point 1.4390

on the Pearson scale. In other words, on the 7 per cent. basis of excellence, the grade "excellent" is easier to reach in a small class than in a large one. If a class is divided arbitrarily into four groups, equal in number, as in the Missouri system, then the lower limit of merit for the top group is .6588 for a class of 100, .6368 for a class of 40, and .5972 for a class of 20. Twenty-five per cent. of a class of 51 members is 13, but only 12 of these have a mark above .6588 on the Pearson scale. Such variability of standards does violence to our sense of scientific rigor, though the practical results do not usually differ, owing to the fact that in practise only integral numbers apply.

In a scientific marking system the first requisite is uniformity of standards of reference. Lack of uniformity is sufficient reason for rejecting the classification into groups on the percentage basis, as in the Missouri system and others, unless that basis has some advantages which compensate for its theoretical defects. Such advantages it is difficult to discover.

To summarize, our proposed plan of marking is as follows:

1. A system of preliminary marking is used, merely to determine the rank of the students.

2. After the rank is fixed, each student is assigned the marks given in our table, with such slight modifications of the marks as are necessary in the judgment of the instructor.

The advantages of this system are:

1. It rests upon correct statistical theory.

2. The groups called "superior," "medium," "inferior" cover equal ranges of ability. These ranges are constant, no matter what the size of the class may be. Neither the top group called "excellent," nor the bottom group called "poor" has a fixed extreme limit, thereby providing, as the system should, for the grading of men of genius at one end and of the intellectual sluggards at the other.

3. It tends to eliminate the personal equation of the examiner.

4. The method is absolute, except in the determination of the deviations of the marks of a class from the *average* marks of classes of that size.

"This is a complicated system," you will say. So it is, though not quite so complex, perhaps, as it appears at first sight. Chemists and physicists know that any process of exact measurements requires time, patience and skill. That is true of our plan.

FLORIAN CAJORI

COLORADO COLLEGE,
COLORADO SPRINGS

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

SECTION B—PHYSICS

SECTION B—Physics—of the American Association for the Advancement of Science held its meetings jointly with the American Physical Society during the convocation week beginning December 29, 1913, at the Georgia School of Technology.

Professor Anthony Zeleny, of the University of Minnesota, was elected vice-president of the section for the ensuing year. There were also elected to the Sectional Committee, Professor D. C. Miller, Case School of Applied Science, 4 years, and Professor G. W. Stewart, University of Iowa, 5 years.

As customary in the past all the shorter and more technical physical papers were given under the auspices of the American Physical Society. On the other hand the longer papers, and, in this case, those that dealt especially with geophysical problems, were grouped together and given under the auspices of Section B. These were:

The Methods of Physical Science, to What are They Applicable?: ARTHUR G. WEBSTER.

This was the vice-presidential address, and is given in full in SCIENCE, 39, pp. 42–51, 1914.

The Present Status of the Magnetic Survey of the Earth: L. A. BAUER.

A concise summary was given in this paper of some of the more important investigations undertaken, and conclusions reached, by the department of terrestrial magnetism of the Carnegie Institution of Washington. The great progress of the magnetic survey of the earth, as conducted by this institution, both over land and over water, was shown on a projected map. Many thousands of miles, even hundreds of thousands, have been traversed in obtaining the data necessary to the accurate magnetic mapping of the earth; nor were the routes followed along the safe and beaten tracks of travel, but rather across the least fre-